An Expert Assistant System to Support the General Observer Program for NGST

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ABSTRACT

One of the manually intensive efforts of Hubble Space Telescope (HST) observing is the specification and validation of the detailed proposals for scientists observing with the telescope. In order to meet the operational cost objectives for the Next Generation Space Telescope (NGST), this process needs to be dramatically less time consuming and less costly. We are prototyping a new proposal development system, the Scientist's Expert Assistant (SEA), using a combination of artificial intelligence and user interface techniques to reduce the time and effort involved for both scientists and the telescope operations staff. The Advanced Architectures and Automation Branch or Goddard's Information Systems Center is working with the Space Telescope Science Institute (STScI) to explore SEA alternatives, using an iterative prototype-review-revise cycle. We are testing the usefulness of rule-based expert systems to painlessly guide a scientist to his or her desired observation specification. We are also examining several potential user interface paradigms and explore data visualization schemes to see which techniques are more intuitive. Our prototypes will be validated using HST's Advanced Camera for Surveys (ACS) instrument (scheduled for installation in 1999) as a live test instrument. Having an operational test-bed will ensure the most realistic feedback possible for the prototyping cycle. In addition, when the instruments for NGST are better defined, the SEA will already be a proven platform that simply needs adapting to NGST specific instruments.

Keywords: NGST, SEA, rule-based systems, visual tools, proposal development

1. BACKGROUND

The SEA is a prototype effort supporting pre-phase A development for the NGST. The objective for SEA is to develop and test new approaches and tools to support the development of observing proposals. The NGST goal is to reduce the staffing requirements for NGST's proposal support staff by 50-80% as compared to HST. In order to accomplish this, the software support tools need to have a great deal more "intelligence" built into them to give observers the supporting guidance with little or no assistance of the telescope's staff. Our SEA Team includes a small group of software engineers and astronomical scientists from Goddard Space Flight Center (GSFC) and STScI.

2. INITIAL ANALYSIS

During the first several months of the project, the team spent most of its time understanding the existing proposal process and tool set in use at STScI to support HST[1]. We evaluated a series of potential tools and development environments. We developed a proposed strategy and tool set and a development and test schedule. Based on this analysis, the team believes that the combination of new visual tools and a rule-based expert assistant will have the biggest impact. Our driving philosophy is that the system must let scientists be scientists and not try to make them instrument or software engineers in order to develop their proposals. The tools should bring relevant reference material to the scientists' fingertips when needed. The tools should minimize duplication of effort, integrate information together, and point the way to defining good programs. The tools should spot problem areas early and be smart enough to recommend alternatives.

In addition to analyzing the existing processes, the team has developed a road map for developing and testing SEA. Since the SEA system will be almost completely new software, it is critical to have a realistic environment in which to perform final evaluation. Consequently, we intend to use ACS as an operational testbed. SEA is not currently intended to be the

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operational platform for ACS proposals, rather it is a parallel development effort. In doing so, we will have the full complexity of an operational environment. We can then compare the time and effort involved in developing a proposal using the both current HST tools and SEA.

Our main philosophy for development of the SEA is:

- The system should be *intelligent*. It should employ artificial intelligence methodologies and paradigms to assist and guide the scientist in producing a proposal that is flight ready.

- The system should be *intuitive*. The user interface should not require extensive training. Scientists should be able to use SEA with little or no assistance.

- The system should be *distributed*. It should allow delivery and processing of proposals via the World Wide Web across a wide range of computing systems.

- The system should be *adaptable*. As the telescope staff learns how best to use NGST once it is launched and operational, the system should be able to incorporate new information and knowledge easily.

- The system should be easily *integrated* with other NGST planning and operations modules.

- The system should be *flexible*. Since NGST is not scheduled for almost a decade, the system development must allow for changes in technology. Further, much of the process of developing observing proposals is common among observing platforms. This system could and should be an effective alternative for other observatories, both present and future.

We have been looking at both the overall process, and emerging technologies to see how the process can be better supported through automated means. We are currently in the middle of the second Phase of this project, which is the first of two development phases for implementing and testing SEA and evaluating its effectiveness. In our development phase, we e are presently developing several related modules and interfaces that will integrate the modules together. Throughout these modules we have several guiding principals driving the development:

- Integrate the various computational tools to minimize or eliminate duplicate entry of the same information. For example, once the instrument mode and targets have been specified, the scientist should not have to go to a separate exposure calculator tool, re-enter that information to obtain exposure times, and manually enter those exposure times back into the proposal. In addition, if the scientist has "jumped ahead" in a process and the system needs information that has not yet been specified, the system should ask for the information when needed (not just kick the user back to a different place in the software).

- Standardize the interface for the computational tools across the different instruments in order to decrease the learning curve and increase efficiency.

- Thoroughly integrate reference material, providing an intelligent context-sensitive means to helping scientists find relevant technical reference material quickly and easily.

3. PROGRESS AND PLANS

During Phase I of the project, the team focused on gaining an overview of the proposal process and defining the scope and schedule for the prototype effort. We reviewed the overall STScI process for detailing observing proposals (known as the Phase II proposal), and the areas within in this process that are currently manually intensive. We also began developing the rules for prototyping an instrument configuration module for ACS. In the process of our analysis, we've chosen to develop two related covering interface approaches that will tie the system together:

Proposal Browser interface

The browser interface will manage the overall proposal process and provide the integration between specific editing modules. It will provide a GUI (Graphical-User-Interface) framework within which a suite of visual modules can be used. A sample of a Browser screen is shown in Figure 1.

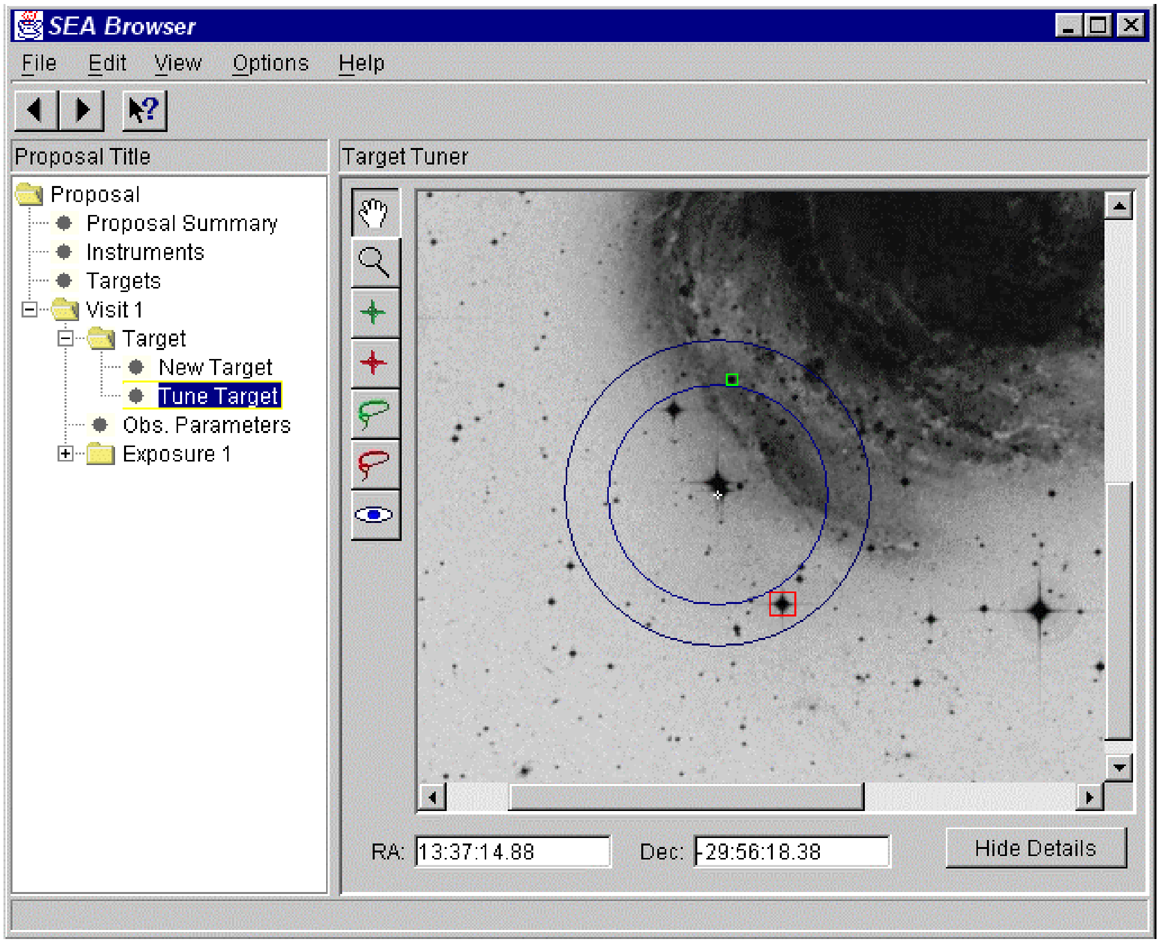

Figure 1, Sample screen from Browser Interface

Proposal Interview interface
This interface integrates rule-based technology with a graphical interface to conduct a dynamic, guided interview with the scientist. The Interviewer will ask the scientist to describe the science they want to accomplish and then recommend (with justifications) a set of parameters for the observations. For example, while specifying an instrument's parameters, the Interviewer might ask the user for the type of observation and the wavelength range and then recommend a filter to the user. If several filters meet the desired wavelength range, the Interviewer could evaluate what it knows of the specified target's spectrum and recommend one of the filters, or it could provide an analysis of the pros and cons of different eligible filters and allow the scientist to select the best one. A sample of what an Interview screen might look like is shown in Figure 2.

SEA's interview mode will be best suited for the occasional user, and for users entering a new proposal from scratch. Users very familiar with the software and the instruments will find the browser mode more efficient, as may users performing minor edits on a nearly complete proposal. Users will be able to move between the Browser and Interview mode at any time.

Both interfaces will be module-based, meaning that several related modules can be inserted to provide specific subsets of functionality. Among the modules we are developing are:

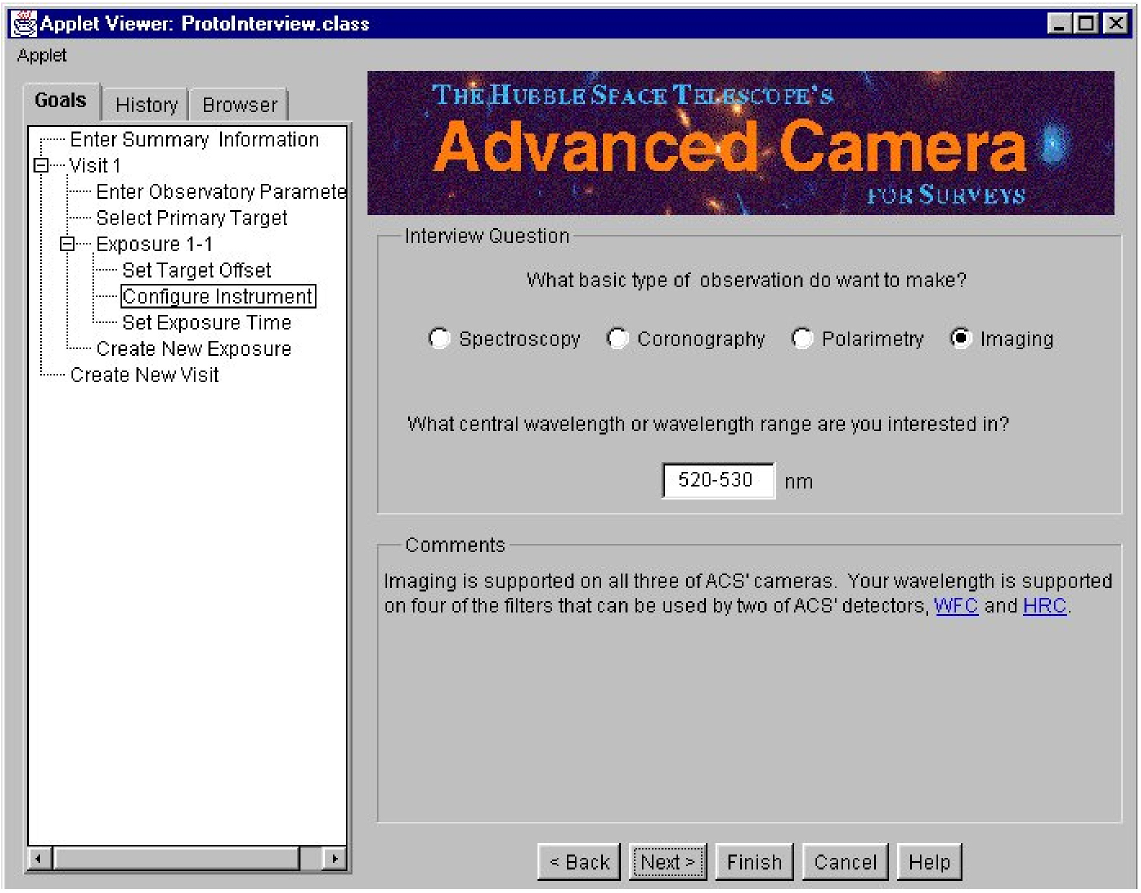

Figure 2 Sample of screen from Interview interface

Target Selector

This module will be a query-based interface to allow the user to select targets from data sources such as the NASA Extraterrestrial Database (NED), or SIMBAD for information on potential targets and have SEA automatically read in the target information (such as location, magnitude, distance, shape, and spectral characteristics).

Visual Target Tuner (VTT)

Once a target's location has been specified, the VTT will provide a graphical tool for fine tuning target coordinates and orientation. For example, currently if an observer needs to include or exclude specific objects from the FOV, they must manually calculate an exact location and orientation for the instrument. Giving a precise orientation requirement significantly hampers the schedulability of their program. The VTT will allow a user to visually select the areas that need to be included or excluded and can then determine a range of acceptable orientations. Further, there are currently no visual tools to help predict other issues in determining the final position for the telescope, such as the impact of diffraction spikes, CCD bleeding. The VTT seeks to be that visual environment. We are planning to prototype the VTT in several phases. The first phase we expect to be demonstrating at this symposium (1998 SPIE's Symposium on Astronomical Telescopes and Instrumentation, March 1998). In the first release the user will be able to display and manipulate a single FITS image, allow the user to specify inclusion or exclusion areas, and fine tune the specific location. In later phases, we will add the ability to display and manage astronomically objects symbolically, model diffraction spikes, simulate detector bleeding, and FOVs. The VTT is described further in an article entitled "Visual Tools to Support Proposal Submission" also included in these proceedings.

Graphical, "Real-Time" Exposure Calculator
Most on-line exposure calculators ask you to enter a series of parameters and then return a single Signal-to-Noise ratio (SNR) for a given time, or visa versa. The SEA calculator is a Java applet that generates real-time interactive graphs showing a whole series of SNRs across a range of exposure times. The tool will allow the scientist to edit target or instrument parameters and immediately see the effect on exposure times or SNRs. In addition to graphing SNR and exposure time, the tool will be able to show instrument and filter transmission curves quickly and easily. We completed a beta release of this tool for the HST's Advanced Camera for Surveys team at the end of December 1997 and will be demonstrating the tool at this symposium. In later phases we expect to integrate the Exposure Calculator and the VTT so that a user can "see" a simulated image. This simulated image would predict what the observation would look like given known information about the target and the instrument such as data from previous images, characteristics of the observatory, detectors and filters. The ETC is described further in an article entitled "Visual Tools to Support Proposal Submission" also included in these proceedings.

Instrument Configuration Expert System (ICES)
This module is the first of the Interview mode tools. It is a rule-based expert system that will guide the observer through the definition of instrument parameters by asking a series of science-based questions, and then providing recommended settings for the instrument based on the answers received. At this symposium we will be demonstrating the first prototype of ICES. It will have a fairly small rule-system that will focus on filter selection. While we do not expect the interview capabilities at this stage to be very comprehensive, later phases will be able to guide an observer through all of the instruments modes and features, and eventually into a multi-exposure visit planner (described below). This first phase of ICES has the primary goal of designing and developing the interface and underlying communication with the Browser mode and other SEA modules. It also serves as the prototype for defining the look-and-feel of the tool's user-interface.

The second phase of the ICES will concentrate on expanding the rules and capabilities of the system substantially. This is a critical objective for the SEA. We are striving to discover if the tool can contain a sufficient level of science expertise to significantly reduce the support needed from STScI scientists. To accomplish this, the tool must contain the required expertise and consistently provide accurate and quality recommendations. Equally critical, the system has to present its information to the scientists in a manner that they will accept.

Visit/Observation Planner Expert System (VPES)
Thus far the modules described have focused on defining a single exposure, both target parameters through the VTT and instrument parameters through the ICES. The Visit Planner Expert System will work to provide assistance in laying out multiple exposures and planning "visits". Both observers and STScI staff currently spend a great deal of time planning visits. These challenges include:

- Laying out multiple exposures to create a mosaic across a large target.
- Imaging a single target with a variety of instrument configurations.
- Planning not just the individual exposure times, but also the overhead time necessary to perform other tasks such as guide star acquisition, instrument overheads and telescope slew.

These are currently manual, iterative processes that involve balancing exposure times to achieve the desired science objectives while keeping within the overall time constraints. The VPES will be an expert system that will query the observer with a series of questions about their science objectives and priorities. It will be able to recommend an optimal trade-off between individual exposure times and total visit execution time.

Development of VPES has not yet begun. Its development will be a primary focus of the team in fiscal year 1999.

Re-validation Agent
This module has not yet been fully analyzed and development of the module will not begin for over a year. Currently, the Program Coordinators at the Institute spend a great deal of time re-processing already approved, but still pending proposals when a change to the instrument occurs. These changes can include a variety of things, for example, new calibration information that affects optimal exposure times. Currently, the concept for the re-validation agent is to use agent-based technology to evaluate the impact of changes to both submitted proposals and proposals that are still under development. The

agent could seek out impacted proposals, calculate the effect of the impact, develop a recommendation and then notify the observer and observatory staff of possible alternatives.

4. TECHNOLOGIES BEING USED

Since the focus of this project is software for more distant future use, we are intentionally trying to stretch existing software technologies and are aggressively using new and emerging components and development environments. To promote widespread usability in a community that uses several different operating systems, SEA is being developed in the latest version of Java and Sun's new Java Foundation Classes (known more commonly by the code name Swing).

In order to integrate rule-based technology we are using Neuron Data's Advisor/J Java-based rules development environment. Advisor/J is a 100% Java rule-based system that includes a graphical rule editor and interactive debugging tools that will assist us in developing and maintaining larger and more complex rule sets. Advisor/J also provides the ability to incorporate a rule-based engine in a fully distributed application. This will allow SEA to process rules on a user's local machine without constantly requiring server-based information or processing.

5. CONCLUSIONS

At this point, we have a prototype framework in place, and an underlying design scheme that we believe will support the fully developed system. We also have an initial prototype for the browser interface, the exposure calculator module, the visual target tuner module, and the instrument configuration interviewer that is available for demonstration at the '98 SPIE Symposium. While it is still too early to judge the effectiveness of the tools, we are encouraged by the initial enthusiasm that the prototypes have generated. We are also encouraged by the ability of the still fairly young Java technology to integrate and distribute applications using different technologies such as a rule-based engine with a fairly separate user interface system. Our primary challenge now is to ensure that we develop a rule-base that is both scientifically sound, comprehensive, and reliable enough to provide the observers with guidance so that they will neither need nor miss a large human support staff. Our secondary challenge is to stay in synch with developing software technology so that our development environment will remain current as SEA's capabilities grow and mature.

REFERENCES

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